FORECASTING A ONE QUARTER DECLINE IN CANADIAN REAL GDP WITH PROBIT MODELS

Carl Gaudreault and Robert Lamy

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ABSTRACT

This paper examines the capacity of a variety of macroeconomic indicators to forecast a one-quarter decline in Canadian real GDP using a standard probit model. We find the U.S NAPM overall index to be the best single coincident predictor of a one-quarter decline in Canadian real GDP followed very closely by employment growth. The information content of the index is enhanced when used in combination with employment growth in the current quarter. For a forecast horizon of one and two quarters, growth in the Finance index of leading indicators of Canadian economic activity and growth in real M1 are the best single leading predictors as they have the highest information content. Growth in real M1 adds the most to the predictive capacity of the leading index and vice-versa. Beyond a forecast horizon of two quarters, the yield curve has the most information content in forecasting a one-quarter decline in Canadian real GDP.

The paper also assesses the reliability of probit models in forecasting a one-quarter decline in Canadian real GDP for forecast horizons from zero to two quarters. In- and out-of-sample, the most reliable model has a forecast horizon of one quarter. It includes the growth in the Finance index of leading indicators of Canadian economic activity lagged one quarter and the growth in real M1 lagged two quarters. In-sample, the model predicted 63 per cent of the nineteen quarterly declines in Canadian real GDP since the first quarter of 1969. Out-of-sample, the success rate since the first quarter of 1980 is 71 per cent.

RÉSUMÉ

Ce papier étudie l'aptitude de plusieurs variables macro-économiques à prévoir une diminution du PIB réel canadien dans un trimestre donné en utilisant des modèles probit standards. Nous trouvons l'indice NAPM agrégé des États-Unis comme étant la meilleure variable coïncidente de prévision d'une diminution trimestrielle du PIB réel du Canada, suivi de très près par la croissance de l'emploi. Le pouvoir prédictif de l'indice NAPM est amélioré lorsqu'il est utilisé conjointement avec le taux de croissance de l'emploi du trimestre courant. Sur un horizon de un et deux trimestres, les meilleures variables de prévision sont respectivement l'indice économique avancé pour le Canada construit par le ministère des Finances, et le taux de croissance de la masse monétaire réelle M1. Cette dernière variable ajoute le plus au pouvoir prédictif de l'indice avancé et vice versa. Sur un horizon de plus de deux trimestres, la courbe de rendement contient plus d'information prédictive que toutes les autres variables pour la prévision d'une diminution du PIB réel du Canada.

Le papier examine également la fiabilité des modèles probit quant à la prévision d'une diminution du PIB réel américain sur un horizon de zéro à deux trimestres. En échantillon et hors échantillon, le modèle le plus fiable est celui avec un trimestre comme horizon de prévision, soit celui avec le taux de croissance de l'indice économique avancé retardé d'un trimestre et le taux de croissance de M1 réelle retardé de deux trimestres. En échantillon, il a su prévoir 63% des dix-neuf diminutions trimestrielles du PIB réel du Canada depuis le premier trimestre de 1969. Hors échantillon, le taux de succès s'élève à 71% depuis le premier trimestre de 1980.

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1. INTRODUCTION

Economists use specialized models to evaluate the information content of economic indicators in forecasting future economic activity. But their models generally focus on predicting a shift in the business cycle regime (see for example Estrella and Mishkin (1998)). Our goal is different, as we want to assess the information content of a wide variety of macroeconomic indicators in forecasting one quarterly decline in Canadian real GDP rather than two consecutive quarters of decline as in our existing models (Lamy (1998)).

The paper is organized as follows. Section 2 presents the data and the model used to assess the information content of macroeconomic indicators. Section 3 describes the results. Section 4 assesses the reliability of probit models in forecasting a one-quarter decline in Canadian real GDP. Key empirical findings are summarized at the end.

2. THE DATA AND THE MODEL

We evaluate the information content of about thirty coincident and leading economic indicators of the Canadian economy, covering its key sectors and markets. Because Canada is an open economy, the list includes a number of coincident and leading indicators of foreign economic activity, notably for U.S., Europe and Japan. All the series are quarterly, seasonally adjusted[1] and stationary. Table 1 (page 5 and 6) contains the list and symbols of all macroeconomic indicators.

The information content of each individual indicator at different lags is determined with a standard probit model. Its general specification, which models the probability of a one-quarter decline in economic activity in the current quarter, is:

$$[1] \quad \mathrm{P}(Y_t = 1) = F(\beta_0 + \beta_1 X_{i,t-k}), \qquad \forall \ k = 0, 1, 2, ..., 7.$$

where the dependent variable, Y_t, is a binary variable taking the value of one when the first difference of real GDP is negative and zero otherwise. $X_{i,t}$ are the macroeconomic indicators and the β's are the parameters of the model which are estimated using maximum likelihood. F is the normal cumulative distribution and k is the number of lags (or the forecast horizon). The estimation period for all probit models is the first quarter of 1969 to the first quarter of 2001, a period that includes nineteen negative quarters.

[1] Except for interest rates and stock market variables.

TABLE 1
LIST OF THE MACROECONOMIC INDICATORS

DOMESTIC INDEXES OF LEADING INDICATORS OF ECONOMIC ACTIVITY	
Growth in Statistics Canada index of leading indicators of economic activity (smoothed)	SCLEIS
Growth in Statistics Canada index of leading indicators of economic activity (unsmoothed)	SCLEIU
Growth in Finance Canada index of leading indicators of economic activity	FLEI
CONSUMPTION INDICATORS	
Growth in unit car sales	SCAR
Consumer confidence actual index	CC
INVESTMENT INDICATORS	
Growth in existing home sales	EHS
Growth in residential building permits, in units	BPR
Growth in housing starts	HS
Growth in non-residential building permits, in units	BPNR
INVENTORY INDICATORS	
Difference in inventory-sales ratio, manufacturing sector	ISR
FOREIGN COINCIDENT INDICATORS OF ECONOMIC ACTIVITY	
Growth in industrial production	IP
NAPM manufacturing aggregate index	NAPM
NAPM manufacturing production index	NAPMP
Growth in U.S. Conference Board index of coincident indicators of U.S. economic activity	USCBCEI
FOREIGN LEADING INDICATORS OF ECONOMIC ACTIVITY	
Growth in U.S. Conference Board index of leading indicators of U.S. economic activity	USCBLEI
Growth in Finance Canada index of leading indicators of U.S. economic activity	USFLEI
Growth in OECD index of leading indicators of European	EURLEI
Growth in OECD index of leading indicators of Japan	JAPLEI
LABOR MARKET INDICATORS	
Growth in total employment	EMP
Growth in help-wanted index	HWI
PRICE INDICATORS	
Growth in CRB future commodity price index in Canadian dollars	CRBFPRI

TABLE 1 (continued)

MONETARY INDICATORS	
Growth in real M1	RM1
Growth in real M2	RM2
INTEREST RATE INDICATORS	
Difference in long-term real interest rate (CPI core inflation)	DRLT
Difference in short-term real interest rate (CPI core inflation)	DRST
SPREAD INDICATORS	
Yield curve, Government bond yield over 10 years – commercial paper rate	YCA
Yield curve, Government bond yields, over 10 years – 1-3 year	YCB
FISCAL POLICY INDICATORS	
Difference in federal budget balance, as a share of GDP	GBF
STOCK MARKET INDICATORS	
Growth in real TSE stock market index	RTSEI
Growth in real S&P500 stock market index	RSP500

We use two criteria to assess the information content of the indicators. The first is the pseudo-R^2, a quantitative measure that was developed by Estrella (1998). The pseudo-R^2 is a measure of the goodness of fit of an estimated probit model.[2] Like the R^2 from a linear regression model, the value of the pseudo-R^2 lies between zero and one. A value close to zero indicates that the model has low predictive capacity for recessions, while a value closer to one means the opposite. This criterion permits the ranking of each series in terms of predictive capacity. The second criterion is the *t*-statistic. We will apply the usual statistical tests to indicate whether the coefficient on a macroeconomic indicator is different from zero at a 5 per cent confidence level.

3. INFORMATION CONTENT OF MACROECONOMIC INDICATORS

As previously indicated, the information content of a given indicator is assessed at lags from zero to seven quarters. We present first the best single predictors of a one-quarter decline in Canadian real GDP for all lags *k*. We then examine if the predictive power of the best single predictors for $k = 0$ to 3 can be enhanced by adding another variable to the probit model.

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[2] The pseudo-R^2 is given by $1 - (\log L_u / \log L_c)^{(-2/n) * \text{Log } L_c}$, where L_u is the likelihood value of the estimated model, L_c is the likelihood value of a probit model containing only a constant as regressor, and n the number of observations in the sample.

3.1 *Best single predictors*

Table 2 (page 9) provides only the results for best single predictor of a one-quarter decline in Canadian real GDP for forecast horizon k by sector or markets. Detailed results are available from the authors. For each lag k, the results in bold correspond to the indicator with the highest pseudo-R^2.

When the forecast horizon $k = 0$, i.e. using all data available to forecast the current quarter, the U.S. NAPM aggregate index (NAPM) is the variable with the highest information content The pseudo-R^2 is equal to 0.313, a value that is only marginally higher than the pseudo-R^2 associated with employment (EMP).[3] Furthermore, as shown by the t-statistic, the NAPM index is statistically significant up to $k = 2$. But its predictive capacity, as measured by the pseudo-R^2, declines dramatically for lags beyond one quarter.

When $k = 1$, the results reveal that the Statistics Canada (SCLEIS) and Finance Canada indexes of leading indicators of Canadian economic activity (FLEI) have the highest information content. For both variables, the pseudo-R^2 is respectively equal to 0.272 and 0.262.[4]

When $k = 2$, the results reveal that growth in real M1 (RM1) and Finance Canada's index of leading indicators of economic activity (FLEI) have the highest information content in forecasting a one-quarter decline in Canadian real GDP. For both variables, the pseudo-R^2 is respectively equal to 0.222 and 0.216.

When k is beyond two quarters, the yield curve (YCA) has the most information content. Its pseudo-R^2 reaches a peak of 0.234 when lagged three quarters and declines thereafter. Up to $k = 8$, the variable remains statistically significant. The yield curve has more predictive power than any other indicator.

3.2 *Could the information content be enhanced?*

This section examines whether the addition of another variable would help to increase the information content.[5] To examine this issue, we re-estimated the probit model for each variable by adding in turn a second explanatory variable at different lags. The variable enhances the predictive capacity of these three variables when the coefficient associated with the added variable is statistically different from zero at 5 per cent. The models that are estimated are specified below:

$$[2] \quad P(Y_t = 1) = F(\beta_0 + \beta_1 NAPM_t + \beta_2 X_{i,t-k}) \quad k = 0,...,7$$

$$[3] \quad P(Y_t = 1) = F(\beta_0 + \beta_1 FLEI_{t-1} + \beta_2 X_{i,t-k}) \quad k = 1,...,7$$

$$[4] \quad P(Y_t = 1) = F(\beta_0 + \beta_1 FLEI_{t-2} + \beta_2 X_{i,t-k}) \quad k = 2,...,7$$

$$[5] \quad P(Y_t = 1) = F(\beta_0 + \beta_1 YCA_{t-3} + \beta_2 X_{i,t-k}) \quad k = 3,...,7$$

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[3] Growth in employment has about 50 per cent more information content in predicting a one-quarter decline in Canada real GDP compared to what Gaudreault and Lamy (2001) found for growth in U.S. employment.

[4] It is worth noting that for the Statistics Canada index of leading indicators of Canadian economic activity the pseudo-R^2 associated with $k = 0$ is marginally higher than at $k = 1$, suggesting that the index is more a coincident than a leading indicator of future growth in the economy.

[5] We choose FLEI instead of SCLEIS because, as explained in the previous footnote, the latter leading index is more a coincident than a leading indicator of future growth in the economy.

where k is the number of lags on the variable X_t. The coefficients are estimated from the first quarter of 1969 to the first quarter of 2001. Tables 3 to 6 from page 10 to 13 provide a summary of the results. The visual inspection of Tables 3 to 6 reveal the following key facts:

- For $k = 0$, growth in employment (EMP) in the current quarter adds the most to the predictive capacity of the NAPM aggregate index in forecasting a one-quarter decline in Canadian real GDP (Table 3). The pseudo-R^2 increases by 25 per cent to 0.390 and the variable is statistically significant at 5 per cent.
- For $k = 1$, growth in real M1 lagged two quarters adds substantial information content to the growth in Finance Canada leading index (FLEI) (Table 4). The pseudo-R^2 increased by 29 per cent and the variable is statistically significant at 5 per cent. As shown in the Table, growth in the help wanted index (HWI) adds to leading index (FLEI). But it is important to note that HWI is already a component of the leading index.
- For $k = 2$, growth in real M1 lagged two quarters adds substantial predictive capacity to Finance Canada's leading index (FLEI) (Table 5). The pseudo-R^2 increased by 20 per cent and the variable is statistically significant at 5 per cent.
- For $k > 2$, no indicators added predictive content beyond what is already contained in the yield curve (Table 6).

The next section describes briefly and assesses the reliability of the best two-variable probit model in forecasting a one-quarter decline in Canadian real GDP for a forecast horizon of zero, one, and two quarters.

4. FORECASTING A ONE-QUARTER DECLINE IN CANADIAN REAL GDP

4.1 *Description of the models*

The estimation results of the selected four probit models are summarized in Table 7 (page 14). The numbers in parentheses are t-statistics of the estimated coefficients. We also report the pseudo-R^2 -- the measure of goodness of fit.

The first equation is a coincident probit model. It models the probability of a one-quarter decline in Canadian real GDP in the current quarter based on growth in employment and the U.S. NAPM overall index in the current quarter. The two explanatory variables are statistically different from zero at a 5 per cent level and the fit of the model, as measured by the pseudo-R^2, is 0.390.

The second equation, like the next one, is a leading probit model. It models the probability of a one-quarter decline in Canadian real GDP based on growth in real M1 and Finance Canada's index of leading indicators of Canadian economic activity. The two explanatory variables are statistically different from zero at a 5 per cent and the pseudo-R^2 is 0.339.

The third equation is a probit model for a forecast horizon of two quarters. The explanatory variables are again growth in real M1 and Finance Canada's index of leading indicators. The two explanatory variables are again statistically different from zero at a 5 per cent confidence level. The fit of the model, as measured by the pseudo-R^2, is 0.267.

TABLE 2
SUMMARY OF THE ESTIMATION RESULTS FOR ONE-VARIABE PROBIT MODELS
$P(Y_t = 1) = F(\beta_0 + \beta_1 X_{t,t-k})$

		lags = *k*							
Variable X_t	**Statistics**	***k* = 0**	***k* = 1**	***k* = 2**	***k* = 3**	***k* = 4**	***k* = 5**	***k* = 6**	***k* = 7**
CC	Pseudo R^2	0.107	0.103	0.054	0.027	0.011	0.013	0.045	0.048
	t-Stat	-3.519*	-3.413*	-2.447*	-1.545	-0.356	0.099	0.325	0.266
EMP	Pseudo R^2	0.283	0.129	0.009	0.002	0.011	0.010	0.017	0.029
	t-Stat	-4.624*	-3.717*	-1.092	-0.475	1.184	1.121	1.449	1.864
CRBRPRI	Pseudo R^2	0.045	0.029	0.012	0.021	0.000	0.002	0.008	0.001
	t-Stat	-2.288*	-1.858	-1.233	-1.589	-0.103	-0.507	1.007	0.334
BPR	Pseudo R^2	0.007	0.052	0.066	0.021	0.001	0.003	0.024	0.000
	t-Stat	-0.955	-2.463*	-2.742*	-1.615	0.386	0.622	1.760	-0.027
NAPM	Pseudo R^2	0.313	0.201	0.066	0.028	0.013	0.015	0.011	0.010
	t-Stat	-5.158*	-4.494*	-2.833*	-1.890	-1.305	-1.382	-1.193	-1.107
USFLEI	Pseudo R^2	0.053	0.176	0.068	0.030	0.013	0.021	0.019	0.052
	t-Stat	-2.553	-4.119	-2.878	-1.954	-1.279	-1.631	-1.534	-2.530*
SCLEIS	Pseudo R^2	0.273	0.272	0.157	0.042	0.018	0.008	0.007	0.004
	t-Stat	-5.078	-5.020	-4.171	-2.305	-1.521	-1.009	-0.957	-0.686
FLEI	Pseudo R^2	0.104	0.262	0.216	0.157	0.069	0.056	0.039	0.056
	t-Stat	-3.462*	-4.983*	-4.684*	-4.185*	-2.903*	-2.638*	-2.220*	-2.617*
RMI	Pseudo R^2	0.097	0.185	0.222	0.115	0.032	0.045	0.041	0.015
	t-Stat	-3.339*	-4.327*	-4.453*	-3.556*	-1.910	-2.232*	-2.008*	-0.774
DRST	Pseudo R^2	0.117	0.018	0.001	0.023	0.000	0.022	0.004	0.007
	t-Stat	-3.557*	-1.524	0.376	1.695	0.177	1.632	0.679	0.909
YCA	Pseudo R^2	0.040	0.161	0.204	0.234	0.177	0.150	0.097	0.057
	t-Stat	-2.228*	-4.166*	-4.588*	-4.884*	-4.335*	-4.071*	-3.389*	-2.653*
YCB	Pseudo R^2	0.026	0.103	0.195	0.219	0.150	0.106	0.079	0.057
	t-Stat	-1.817	-3.446*	-4.391*	-4.612*	-4.006*	-3.500*	-3.094*	-2.656*
ISR	Pseudo R^2	0.074	0.072	0.035	0.038	0.004	0.010	0.002	0.014
	t-Stat	-2.878*	-2.877*	-2.061*	-2.151	-0.697	-1.116	-0.536	-1.339
GBF	Pseudo R^2	0.068	0.056	0.031	0.054	0.000	0.005	0.007	0.002
	t-Stat	-2.834*	-2.577*	-1.950	2.513*	-0.052	0.811	0.943	-0.445
RTSEI	Pseudo R^2	0.008	0.099	0.094	0.058	0.006	0.000	0.026	0.007
	t-Stat	-1.011	-3.452*	-3.351*	-2.665*	-0.915	0.022	1.749	0.909

Note: The (*) means that the variable X_t is statistically different from zero at the 5 per cent confidence level.

TABLE 3
SUMMARY OF THE ESTIMATION RESULTS:
TWO-VARIABLES PROBIT MODELS FOR CURRENT QUARTER WITH THE U.S NAPM OVERALL INDEX (NAPM)

$$P(Y_t = 1) = F(\beta_0 + \beta_1 NAPM_t + \beta_2 X_{t,t-k})$$

		lags = k							
Variable X_t	**Statistics**	**k = 0**	**k = 1**	**k = 2**	**k = 3**	**k = 4**	**k = 5**	**k = 6**	**k = 7**
SCAR	Pseudo R^2	0.314	0.350	0.318	0.334	0.352	0.316	0.314	0.314
	t-Stat napm	-5.040	-4.835	-5.043	-4.839	-5.166	-5.177	-5.103	-5.151
	t-Stat	0.115	-2.057*	0.717	-1.535	2.018*	-0.540	-0.085	0.326
EMP	Pseudo R^2	0.390	0.328	0.318	0.317	0.314	0.313	0.314	0.317
	t-Stat napm	-3.289	-4.292	-5.028	-5.129	-5.056	-5.133	-4.926	-4.901
	t-Stat	-2.699*	-1.302	0.766	-0.648	0.096	-0.048	-0.236	-0.651
BPR	Pseudo R^2	0.337	0.320	0.318	0.314	0.314	0.322	0.362	0.314
	t-Stat napm	-5.174	-4.785	-4.649	-4.928	-5.129	-5.132	-5.071	-5.147
	t-Stat	-1.634	-0.844	-0.763	0.088	0.253	1.042	2.348*	-0.263
NAPM	Pseudo R^2	NA	0.315	0.314	0.316	0.343	0.399	0.395	0.406
	t-Stat napm	NA	-3.469	-4.709	-5.030	-5.168	-5.165	-4.955	-4.977
	t-Stat	NA	-0.458	0.087	-0.605	-1.871	-2.917	-2.841*	-2.947*
USFLEI	Pseudo R^2	0.317	0.316	0.328	0.365	0.331	0.314	0.314	0.364
	t-Stat napm	-4.778	-3.609	-4.628	-4.590	-4.994	-5.041	-5.019	-4.875
	t-Stat	0.638	-0.528	1.298	2.216*	1.389	-0.180	-0.280	-2.316*
SCLEIS	Pseudo R^2	0.345	0.334	0.316	0.314	0.314	0.314	0.335	0.358
	t-Stat napm	-2.698	-2.508	-3.883	-4.860	-5.036	-5.107	-5.135	-5.004
	t-Stat	-1.926	-1.567	-0.558	0.176	-0.243	-0.284	-1.595	-2.188*
RM1	Pseudo R^2	0.329	0.338	0.353	0.325	0.316	0.322	0.335	0.325
	t-Stat napm	-4.496	-3.777	-3.639	-4.381	-4.953	-4.871	-4.963	-5.054
	t-Stat	-1.371	-1.704	-2.074	-1.179	0.024	-0.703	-1.251	-0.337
DRST	Pseudo R^2	0.316	0.314	0.344	0.338	0.314	0.314	0.322	0.314
	t-Stat napm	-5.041	-5.166	-5.155	-5.197	-5.145	-5.138	-5.175	-5.160
	t-Stat	0.527	0.261	1.870	1.668	-0.230	0.327	-1.025	-0.165
YCA	Pseudo R^2	0.316	0.333	0.328	0.335	0.324	0.333	0.332	0.335
	t-Stat napm	-4.888	-4.001	-3.467	-3.199	-3.766	-4.145	-4.594	-4.921
	t-Stat	-0.547	-1.523	-1.312	-1.598	-1.131	-1.500	-1.490	-1.597
GBF	Pseudo R^2	0.329	0.317	0.326	0.397	0.328	0.313	0.314	0.337
	t-Stat napm	-4.777	-4.728	-4.981	-4.709	-5.105	-5.109	-5.133	-5.127
	t-Stat	-1.351	-0.659	-1.224	2.802*	-1.295	-0.033	-0.290	-1.660
RTSEI	Pseudo R^2	0.313	0.355	0.328	0.318	0.313	0.314	0.344	0.314
	t-Stat napm	-5.011	-4.748	-4.540	-4.772	-5.109	-5.155	-5.105	-5.101
	t-Stat	0.035	-2.222	-1.340	-0.730	0.078	0.205	1.786	-0.252

Note: The first *t*-statistics corresponds to the estimated coefficient associated to $NAPM_t$. It is always statistically different from zero at the 5 per cent level. The second *t*-statistics corresponds to the estimated coefficient associated with the second variable $X_{t,t-k}$. The (*) means that it is statistically different from zero at the 5 per cent confidence level.

TABLE 4
SUMMARY OF THE ESTIMATION RESULTS:
TWO-VARIABLES PROBIT MODELS ONE-QUARTER AHEAD WITH THE FINANCE CANADA'S LEADING INDEX (FLEI)

$$P(Y_t = 1) = F(\beta_0 + \beta_1 FLEI_{t-1} + \beta_2 X_{t,t-k})$$

		lags = k						
Variable X_t	**Statistics**	**k = 1**	**k = 2**	**k = 3**	**k = 4**	**k = 5**	**k = 6**	**k = 7**
CC	Pseudo R^2	0.281	0.275	0.280	0.282	0.291	0.310	0.315
	t-Stat flei	-4.182	-4.537	-4.836	-4.967	-5.011	-4.873	-4.892
	t-Stat	-1.402	-0.904	-0.834	-0.210	0.027	0.282	0.150
HWI	Pseudo R^2	0.306	0.364	0.267	0.279	0.268	0.266	0.280
	t-Stat flei	-3.258	-4.584	-4.926	-5.101	-4.994	-4.912	-5.112
	t-Stat	-2.212*	-3.265*	-0.780	-1.416	-0.851	0.632	-1.481
BPNR	Pseudo R^2	0.269	0.295	0.269	0.269	0.262	0.263	0.278
	t-Stat flei	-4.772	-5.111	-4.975	-4.911	-4.978	-4.955	-5.063
	t-Stat	-0.900	-1.908	-0.903	0.899	0.088	0.123	-1.369
NAMP	Pseudo R^2	0.319	0.300	0.293	0.297	0.336	0.326	0.330
	t-Stat flei	-3.499	-4.742	-4.980	-5.139	-5.085	-5.053	-5.172
	t-Stat	-2.547*	-2.132*	-1.929	-2.046*	-2.797*	-2.595*	-2.623*
USFLEI	Pseudo R^2	0.264	0.263	0.263	0.263	0.275	0.271	0.328
	t-Stat flei	-3.096	-4.247	-4.578	-4.719	-4.909	-4.870	-4.952
	t-Stat	-0.442	-0.107	0.128	0.325	-1.229	-1.009	-2.692*
SCLEIS	Pseudo R^2	0.328	0.313	0.273	0.279	0.274	0.291	0.292
	t-Stat flei	-2.495	-3.989	-4.691	-4.965	-4.994	-5.056	-5.141
	t-Stat	-2.686*	-2.427*	-1.127	-1.413	-1.199	-1.842	-1.861
RMI	Pseudo R^2	0.277	0.339	0.289	0.265	0.290	0.290	0.285
	t-Stat flei	-3.151	-3.532	-4.133	-4.566	-4.788	-4.789	-4.975
	t-Stat	-1.304	-2.803*	-1.760	-0.233	-1.625	-1.347	-0.632
DRLT	Pseudo R^2	0.266	0.273	0.275	0.264	0.267	0.272	0.263
	t-Stat flei	-4.948	-4.912	-4.971	-4.974	-4.968	-5.000	-4.972
	t-Stat	-0.677	1.111	1.232	-0.499	0.721	-1.095	0.124
YCA	Pseudo R^2	0.264	0.267	0.289	0.285	0.299	0.291	0.290
	t-Stat flei	-3.314	-2.603	-2.436	-3.277	-3.846	-4.333	-4.687
	t-Stat	0.451	-0.753	-1.802	-1.636	-2.088	-1.860	-1.827
GBF	Pseudo R^2	0.294	0.302	0.321	0.287	0.264	0.264	0.277
	t-Stat flei	-4.786	-4.982	-4.851	-5.059	-4.956	-4.950	-5.022
	t-Stat	-1.875	-2.091*	2.488*	-1.689	0.429	0.399	-1.301
RTSEI	Pseudo R^2	0.297	0.326	0.300	0.268	0.268	0.271	0.263
	t-Stat flei	-4.427	-4.723	-4.811	-4.979	-5.028	-4.858	-4.961
	t-Stat	-2.054*	-2.734*	-2.117*	-0.851	-0.855	0.970	-0.293

Note: The first *t*-statistics corresponds to the estimated coefficient associated to $FLEI_{t-1}$. It is always statistically different from zero at the 5 per cent level. The second *t*-statistics corresponds to the estimated coefficient associated with the second variable $X_{t,t-k}$. The (*) means that it is statistically different from zero at the 5 per cent confidence level.

TABLE 5
SUMMARY OF THE ESTIMATION RESULTS:
TWO-VARIABLES PROBIT MODELS TWO-QUARTERS AHEAD WITH THE FINANCE CANADA'S LEADING INDEX (FLEI)

$$P(Y_t = 1) = F(\beta_0 + \beta_1 FLEI_{t-2} + \beta_2 X_{i,t-k})$$

		lags = *k*					
Variable X_i	**Statistics**	***k* = 2**	***k* = 3**	***k* = 4**	***k* = 5**	***k* = 6**	***k* = 7**
HWI	Pseudo R^2	0.243	0.216	0.220	0.216	0.217	0.227
	t-Stat flei	-3.336	-4.546	-4.686	-4.672	-4.577	-4.759
	t-Stat	-1.803	0.155	-0.726	0.193	0.367	-1.208
CRBFPRI	Pseudo R^2	0.218	0.248	0.216	0.221	0.216	0.220
	t-Stat flei	-4.598	-4.736	-4.683	-4.709	-4.622	-4.677
	t-Stat	-0.557	-1.867	-0.073	-0.804	0.151	-0.700
BPR	Pseudo R^2	0.223	0.216	0.218	0.222	0.251	0.216
	t-Stat flei	-4.038	-4.415	-4.689	-4.699	-4.716	-4.683
	t-Stat	-0.971	-0.274	0.542	0.920	2.077	-0.015
NAMP	Pseudo R^2	0.216	0.223	0.228	0.257	0.267	0.271
	t-Stat flei	-3.843	-4.430	-4.674	-4.909	-4.932	-4.845
	t-Stat	-0.126	-0.942	-1.245	-2.217	-2.414	-2.427
USFLEI	Pseudo R^2	0.245	0.226	0.220	0.217	0.224	0.264
	t-Stat flei	-4.157	-4.156	-4.329	-4.410	-4.574	-4.571
	t-Stat	1.839	1.089	0.720	-0.414	-1.022	-2.380
SCLEIU	Pseudo R^2	0.239	0.223	0.217	0.219	0.217	0.236
	t-Stat flei	-1.999	-3.818	-4.494	-4.555	-4.664	-4.738
	t-Stat	-1.652	-0.957	0.337	-0.630	-0.372	-1.553
RM1	Pseudo R^2	0.267	0.236	0.220	0.226	0.236	0.231
	t-Stat flei	-2.289	-3.649	-4.263	-4.238	-4.428	-4.510
	t-Stat	-2.345*	-1.563	0.465	-0.816	-1.210	0.245
DRLT	Pseudo R^2	0.249	0.220	0.216	0.225	0.223	0.216
	t-Stat flei	-4.742	-4.633	-4.679	-4.711	-4.733	-4.682
	t-Stat	1.967*	0.759	-0.321	1.050	-0.976	-0.071
YCA	Pseudo R^2	0.230	0.249	0.228	0.233	0.228	0.223
	t-Stat flei	-1.753	-1.323	-2.368	-2.937	-3.662	-4.095
	t-Stat	-1.327	-1.996*	-1.243	-1.447	-1.239	-0.973
GBF	Pseudo R^2	0.228	0.307	0.222	0.217	0.219	0.229
	t-Stat flei	-4.511	-4.696	-4.711	-4.613	-4.656	-4.751
	t-Stat	-1.215	3.035*	-0.904	-0.398	0.678	-1.261
RTSEI	Pseudo R^2	0.249	0.237	0.216	0.216	0.232	0.216
	t-Stat flei	-4.054	-4.362	-4.636	-4.686	-4.610	-4.624
	t-Stat	-2.026*	-1.630	-0.227	0.156	1.377	-0.018

Note: The first *t*-statistics corresponds to the estimated coefficient associated to $FLEI_{t-2}$. It is always statistically different from zero at the 5 per cent level. The second *t*-statistics corresponds to the estimated coefficient associated with the second variable $X_{i,t-k}$. The (*) means that it is statistically different from zero at the 5 per cent confidence level.

TABLE 6
SUMMARY OF THE ESTIMATION RESULTS:
TWO-VARIABLES PROBIT MODELS TWO-QUARTERS AHEAD WITH THE YIELD CURVE (YCA)

$$P(Y_t = 1) = F(\beta_0 + \beta_1 YCA_{t-3} + \beta_2 X_{t,t-k})$$

		lags = *k*				
Variable X_i	**Statistics**	***k* = 3**	***k* = 4**	***k* = 5**	***k* = 6**	***k* = 7**
SCAR	Pseudo R^2	0.261	0.255	0.234	0.241	0.234
	t-Stat yca	-4.521	-4.971	-4.883	-4.874	-4.884
	t-Stat	-1.769	1.532	0.174	-0.900	0.064
HWI	Pseudo R^2	0.235	0.237	0.235	0.242	0.245
	t-Stat yca	-4.815	-4.873	-4.866	-4.829	-4.892
	t-Stat	0.320	-0.646	0.248	0.949	-1.181
EHS	Pseudo R^2	0.248	0.235	0.240	0.234	0.243
	t-Stat yca	-4.450	-4.889	-4.863	-4.883	-4.805
	t-Stat	-1.328	0.317	0.806	-0.023	-1.042
NAPM	Pseudo R^2	0.235	0.243	0.259	0.261	0.269
	t-Stat yca	-4.639	-4.845	-4.915	-4.929	-4.950
	t-Stat	-0.388	-1.059	-1.741	-1.780	-1.995*
USFLEI	Pseudo R^2	0.246	0.239	0.236	0.236	0.273
	t-Stat yca	-4.622	-4.639	-4.687	-4.716	-4.700
	t-Stat	1.201	0.750	-0.536	-0.482	-2.129*
FLEI	Pseudo R^2	0.234	0.237	0.234	0.234	0.247
	t-Stat yca	-2.994	-4.139	-4.304	-4.501	-4.484
	t-Stat	-0.075	0.579	-0.200	-0.175	-1.275
RM1	Pseudo R^2	0.240	0.242	0.244	0.251	0.253
	t-Stat yca	-3.724	-4.651	-4.507	-4.643	-4.846
	t-Stat	-0.847	0.541	-0.026	-0.658	0.275
DRST	Pseudo R^2	0.251	0.235	0.255	0.236	0.234
	t-Stat yca	-4.893	-4.893	-4.938	-4.871	-4.880
	t-Stat	1.410	-0.420	1.534	-0.521	0.042
YCB	Pseudo R^2	0.243	0.234	0.234	0.235	0.235
	t-Stat yca	-1.763	-3.122	-3.741	-4.085	-4.331
	t-Stat	-1.022	-0.184	-0.107	-0.234	-0.253
RTSEI	Pseudo R^2	0.250	0.234	0.237	0.261	0.234
	t-Stat yca	-4.479	-4.845	-4.905	-4.875	-4.763
	t-Stat	-1.377	-0.178	0.602	1.727	0.024

Note: The first *t*-statistics corresponds to the estimated coefficient associated to YCA_{t-3}. It is always statistically different from zero at the 5 per cent level. The second *t*-statistics corresponds to the estimated coefficient associated with the second variable $X_{t,t-k}$. The (*) means that it is statistically different from zero at the 5 per cent confidence level.

TABLE 7
ESTIMATION RESULTS OF THE BEST PROBIT MODELS FOR FORECAST HORIZONS OF ZERO TO TWO QUARTERS
1969:Q1 TO 2001:Q1

[7] $$P(Y_t = 1) = F\left(\underset{(2.928)}{4.749} - \underset{(-3.289)}{0.109}\, NAPM_t - \underset{(-2.699)}{1.165}\, EMP_t\right)$$

$$Pseudo\ R^2 = 0.390$$

[8] $$P(Y_t = 1) = F\left(\underset{(-6.147)}{-1.085} - \underset{(-3.532)}{0.247}\, FLEI_{t-1} - \underset{(-2.803)}{0.290}\, RM1_{t-2}\right)$$

$$Pseudo\ R^2 = 0.339$$

[9] $$P(Y_t = 1) = F\left(\underset{(-6.365)}{-1.054} - \underset{(-2.289)}{0.171}\, FLEI_{t-2} - \underset{(-2.345)}{0.261}\, RM1_{t-2}\right)$$

$$Pseudo\ R^2 = 0.267$$

4.2 *Reliability of the models*

Assessing the reliability of the probit models in forecasting a one-quarter decline is not as straightforward as evaluating the ability of a model to predict the growth rate of any macroeconomic indicator, such as Canadian real GDP. The evaluation of the probit models is more difficult because we cannot compare the estimated probabilities with actual data.

A probit model predicts a one-quarter decline in Canadian real GDP when the estimated probability is equal or above 50 per cent. Using that rule, the forecasting performance of the probit is determined with two statistical criteria. The first criterion is the success rate, which is defined as the number of times a probit model predicted correctly a one-quarter decline in Canadian real GDP as a share of the total number of decline. The second criterion is the number of false signals. A probit model gives a false signal when it incorrectly predicts a one-quarter decline in real GDP.

In-sample forecasting performance

The results, based on the two criteria defined above, for the in-sample forecasting performance of the probit models are reported in Table below. Charts 1a to 1c (pages 16 and 17) show the in-sample estimated probabilities for each probit model along with the percentage change in Canadian real GDP at quarterly rate.

TABLE 8
IN-SAMPLE PERFORMANCE OF THE PROBIT MODELS
IN FORECASTING A ONE-QUARTER DECLINE IN CANADIAN REAL GDP

Probit model for a forecast horizon of	Success Rate	Number of false signals
Zero quarters	53%	0
One quarter	63%	2
Two quarters	63%	3

The most reliable probit model has a forecast horizon of one and two quarters. Both models use growth in both real M1 and Finance Canada's index of leading indicators of economic activity as the information set. Both models forecast correctly twelve of the nineteen declines in Canadian real GDP since the first quarter of 1969 for a success rate of 63 per cent (Charts 1b and 1c). The models provided two and three false signals respectively. The performance of the probit model for a forecast horizon of zero quarters, i.e. the coincident probit model, is less impressive as the success rate is noticeably lower (Table 8 and Charts 1a). However, it gave no false signals over the sample period, less than the other two models.

CHART 1
IN-SAMPLE ESTIMATED PROBABILITIES FROM THE PROBIT MODELS

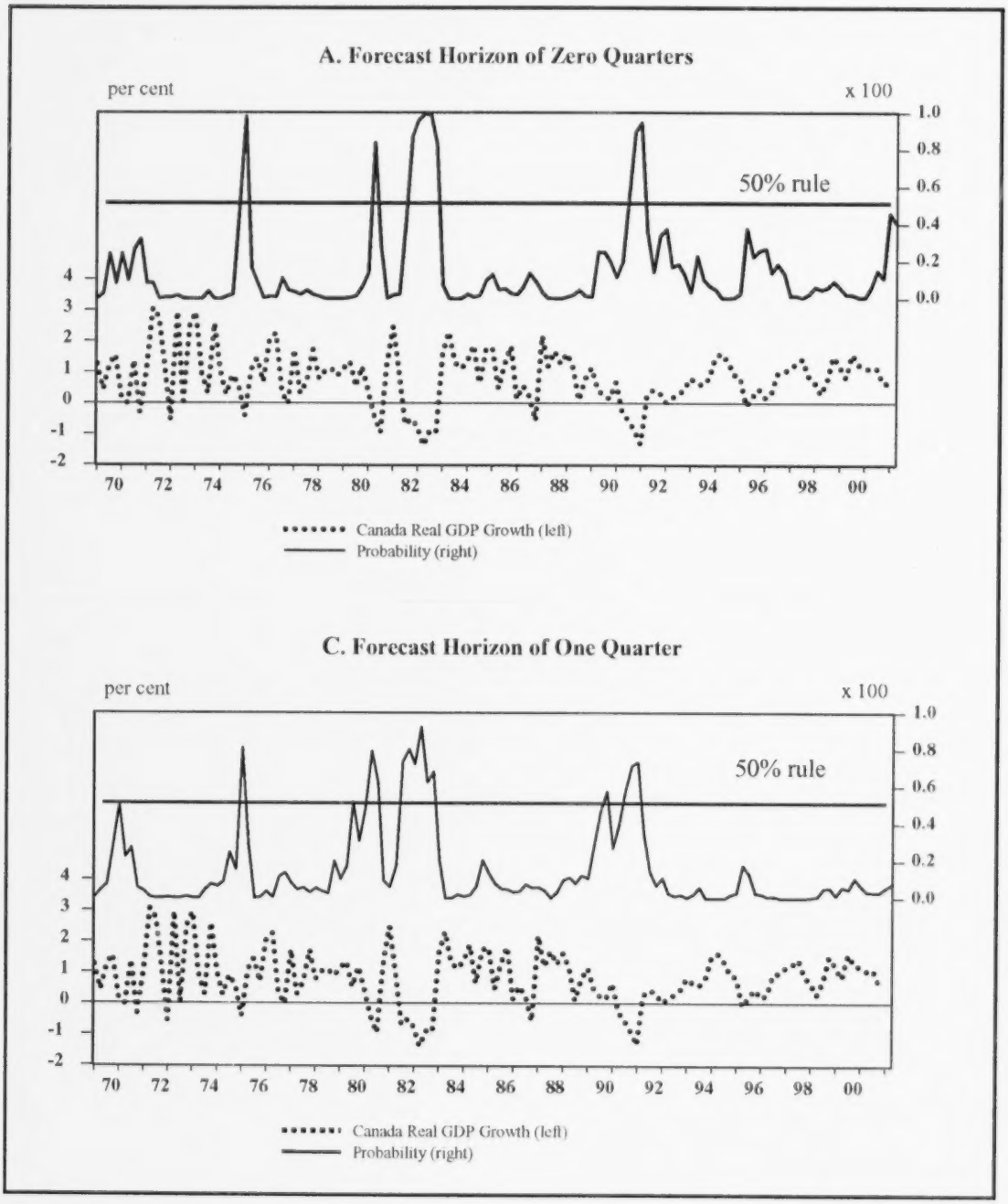
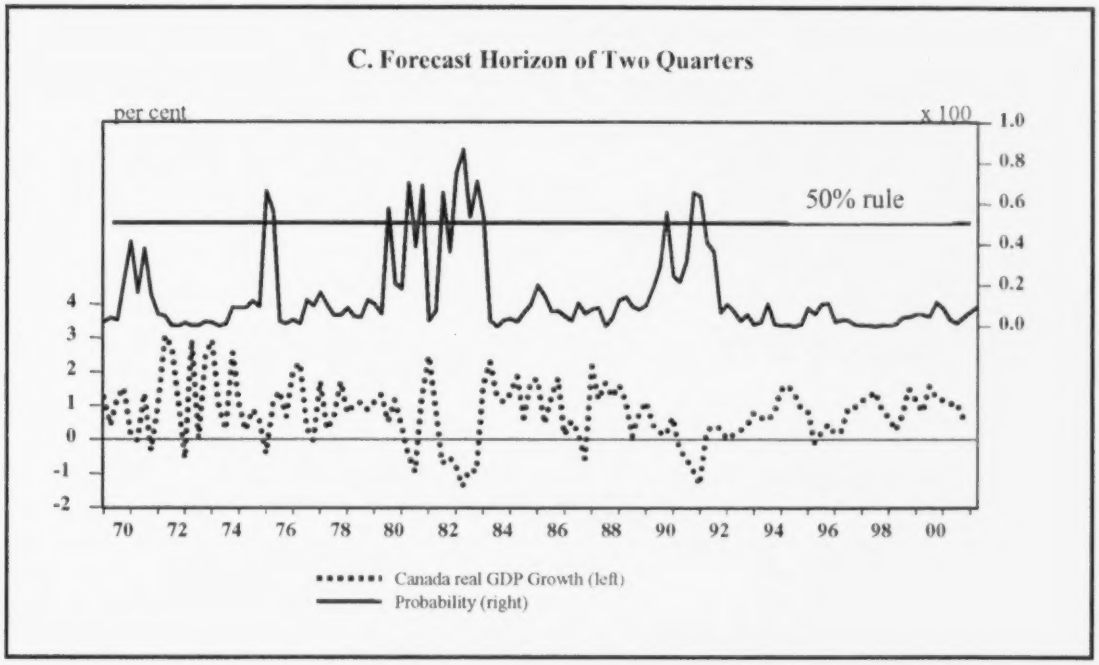


CHART 1
IN-SAMPLE ESTIMATED PROBABILITIES FROM THE PROBIT MODELS



Out-of-sample forecasting performance

Because there is an important issue of over-fitting in searching in-sample for the best information set to predict a one quarter decline in Canadian real GDP for a given forecast horizon, we also performed out-of-sample evaluation of the forecasting performance. This is the most informative and useful test to gauge the real time ability of the models in forecasting the likelihood of any future one-quarter decline in real activity in Canada.

The out-of-sample evaluation was done from the beginning of the 1980s.[6] The out-of-sample estimated probabilities were obtained by using the rolling regression technique. First, the coefficients of each probit model were estimated from the first quarter of 1969 to the fourth quarter of 1979. The estimated coefficients of each probit model were used to compute forecast probabilities for the first quarter of 1980 for forecast horizons of zero to two quarters. We then increased the estimation period by one quarter and produced another set of forecast probabilities for each forecast horizon. This rolling procedure was repeated until the first quarter of 2001, the end of the sample period.

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[6] We restricted the out-of-sample period to the 1980s and 1990s to have a sufficient number of data points to get reliable coefficient estimates for the probit models.

Table 9 gives the results in terms of the success rates and the number of false signals for all probit models. Charts 2a to 2c (pages 19 and 20) illustrate the out-of-sample estimated probabilities for each probit model.

TABLE 9
OUT-OF-SAMPLE PERFORMANCE OF THE PROBIT MODELS IN FORECASTING A ONE-QUARTER DECLINE IN CANADIAN REAL GDP

Probit model for a forecast horizon of	Success Rate	Number of false signals
Zero quarters	64% (64%)	3 (0)
One quarter	71% (79%)	1 (2)
Two quarters	43% (64%)	4 (3)

Note: The numbers in parentheses are in sample results between the first quarter of 1980 and the first quarter of 2001.

The most reliable probit model again has a forecast horizon of one quarter, i.e. the model that uses data up to the previous quarter to provide an estimate of the likelihood of a one-quarter decline in Canadian real GDP (Chart 2b). It is worth noting that the success rate here is relatively higher at 71 per cent compared to the in-sample results. Out-of-sample, the probit model gave one false signal in the last two decades. Another result from Table 9 is the high reliability of the probit model zero-quarter ahead in the 1980s and 1990s. Its success rate is 64 per cent, but it provided, in contrast to the previous model, three false signals in the past 20 years.

CHART 2
OUT-OF-SAMPLE ESTIMATED PROBABILITIES FROM THE PROBIT MODELS

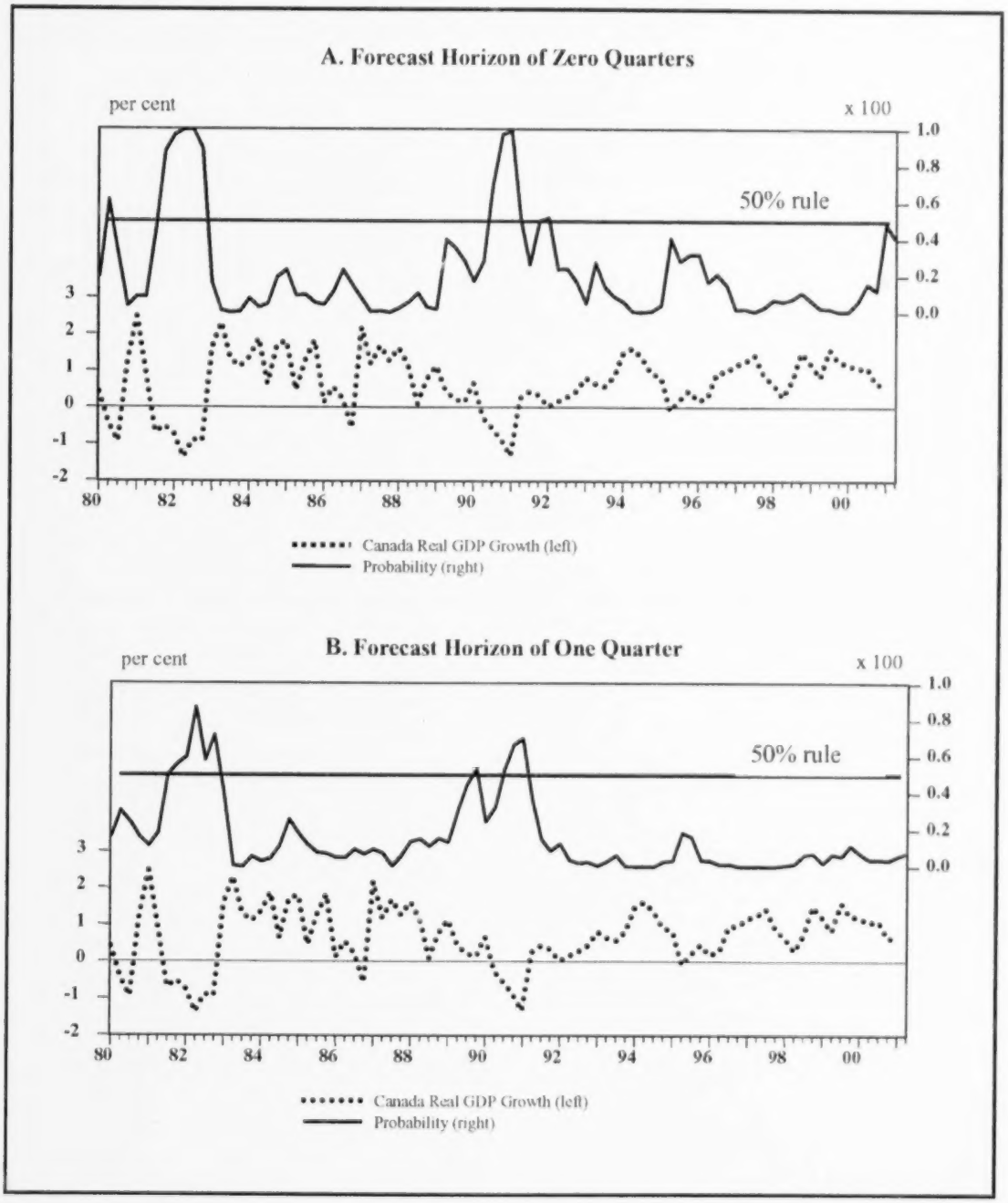
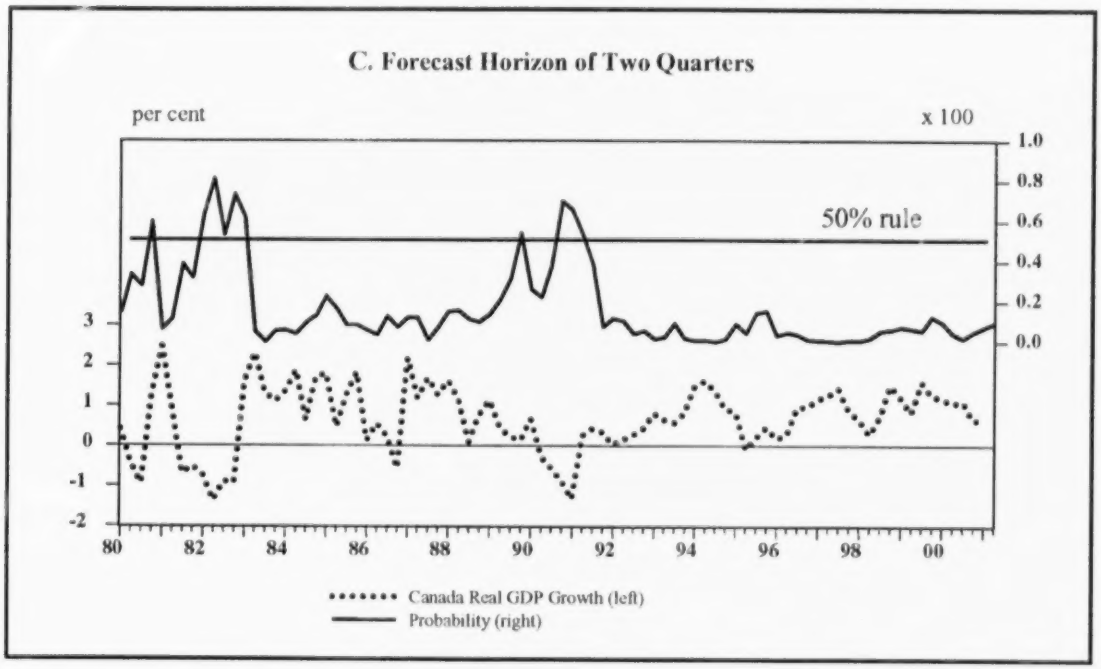


CHART 2
OUT-OF-SAMPLE ESTIMATED PROBABILITIES FROM PROBIT MODELS



5. CONCLUSION

This paper has examined the capacity of a variety of macroeconomic indicators to forecast a one-quarter decline in Canadian real GDP using a standard probit model. We found the U.S NAPM overall index to be the best single coincident predictor of a one-quarter decline in Canadian real GDP followed closely by growth in employment. The information content of the index is enhanced when used in combination with growth in total employment in the current quarter. For a forecast horizon of one and two quarters, growth in Finance Canada's index of leading indicators of Canadian economic activity and growth in real M1 are the best single leading indicators as they have the highest information content. Growth in real M1 adds the most to the predictive capacity of the leading index and vice-versa. Beyond a forecast horizon of two quarters, it is the yield curve that has the most information content in forecasting a one-quarter decline in Canadian real GDP.

The paper has also assessed the reliability of probit models in forecasting a one-quarter decline in Canadian real GDP for forecast horizons from zero to two quarters. In- and out-of-sample, the most reliable model has a forecast horizon of one quarter. It includes the growth in the Finance Canada index of leading indicators of Canadian economic activity lagged one quarter and the growth in real M1 lagged two quarters. In-sample, the model predicted 63 per cent of the nineteen quarterly declines in Canadian real GDP since the second quarter of 1969. Out-of-sample, the success rate since the first quarter of 1980 is 71 per cent.

REFERENCES

Atta-Mensah, J and G. Tkacz, 1998, " Predicting Canadian Recessions Using Financial Variables: A Probit Approach", *Working Paper No. 98-5*, Bank of Canada.

Bernard, H and S. Gerlach, 1996, "Does the Term Structure Predict Recessions? The International Evidence", *Working Paper Series*, No. 37, Bank of International Settlements.

Estrella, A, 1998, "A New Measure of Fit for Equations With Dichotomous Dependent Variables", *Journal of Business and Economic Statistics*, Vol. 16, No. 2, pp. 198-205.

Estrella, A. and F. Mishkin, 1998, "Predicting U.S. Recessions: Financial Variables as Leading Indicators", *The Review of Economics and Statistics*, pp. 45-61.

Gaudreault, C. and R. Lamy, 2001, "Forecasting a One-Quarter Decline in U.S. Real GDP with Probit Models", Mimeo, Finance Canada.

Lamy, R., 1998, "Forecasting Canadian Recessions with Macroeconomic Indicators", *Working Paper Series No 98-01*, Finance Canada.

Appendix A

FIGURE 1
IN-SAMPLE ESTIMATED PROBABILITIES FROM PROBIT MODELS WITH THE QUARTERLY DECLINES IN CANADIAN REAL GDP SINCE 1969

A. Forecast Horizon of *Zero* Quarter

Dates	Canada real GDP growth	Estimated probabilities
1970Q2	-0.02	0.10
1970Q4	-0.32	0.32
1972Q1	-0.56	0.01
1975Q1	-0.42	0.98
1976Q4	-0.03	0.05
1980Q2	-0.44	0.84
1980Q3	-0.95	0.27
1981Q3	-0.70	0.41
1981Q4	-0.51	0.87
1982Q1	-0.75	0.96
1982Q2	-1.38	0.99
1982Q3	-0.89	0.99
1982Q4	-0.94	0.83
1986Q4	-0.57	0.09
1990Q2	-0.28	0.20
1990Q3	-0.56	0.55
1990Q4	-0.90	0.90
1991Q1	-1.33	0.95
1995Q2	-0.09	0.38

B. Forecast Horizon of One Quarter

Dates	Canada real GDP growth	Estimated probabilities
1970Q2	-0.02	0.22
1970Q4	-0.32	0.06
1972Q1	-0.56	0.00
1975Q1	-0.42	0.81
1976Q4	-0.03	0.14
1980Q2	-0.44	0.79
1980Q3	-0.95	0.62
1981Q3	-0.70	0.74
1981Q4	-0.51	0.80
1982Q1	-0.75	0.73
1982Q2	-1.38	0.92
1982Q3	-0.89	0.63
1982Q4	-0.94	0.68
1986Q4	-0.57	0.06
1990Q2	-0.28	0.40
1990Q3	-0.56	0.58
1990Q4	-0.90	0.71
1991Q1	-1.33	0.73
1995Q2	-0.09	0.18

C. Forecast Horizon of Two Quarters

Dates	Canada real GDP growth	Estimated probabilities
1970Q2	-0.02	0.17
1970Q4	-0.32	0.16
1972Q1	-0.56	0.02
1975Q1	-0.42	0.66
1976Q4	-0.03	0.10
1980Q2	-0.44	0.70
1980Q3	-0.95	0.39
1981Q3	-0.70	0.65
1981Q4	-0.51	0.37
1982Q1	-0.75	0.75
1982Q2	-1.38	0.86
1982Q3	-0.89	0.54
1982Q4	-0.94	0.71
1986Q4	-0.57	0.06
1990Q2	-0.28	0.22
1990Q3	-0.56	0.33
1990Q4	-0.90	0.66
1991Q1	-1.33	0.64
1995Q2	-0.09	0.06

Note: The shaded area notifies that the probability to have a quarterly decline in the current quarter is higher than 50%.

FIGURE 2
OUT-OF-SAMPLE ESTIMATED PROBABILITIES FROM PROBIT MODELS WITH THE QUARTERLY DECLINES IN CANADIAN REAL GDP SINCE 1980

A. Forecast Horizon of Zero Quarter

Dates	Canada real GDP growth	Estimated probabilities
1980Q2	-0.44	0.61
1980Q3	-0.95	0.31
1981Q3	-0.70	0.44
1981Q4	-0.51	0.88
1982Q1	-0.75	0.97
1982Q2	-1.38	0.99
1982Q3	-0.89	0.99
1982Q4	-0.94	0.89
1986Q4	-0.57	0.15
1990Q2	-0.28	0.28
1990Q3	-0.56	0.70
1990Q4	-0.90	0.97
1991Q1	-1.33	0.99
1995Q2	-0.09	0.41

B. Forecast Horizon of One Quarter

Dates	Canada real GDP growth	Estimated probabilities
1980Q2	-0.44	0.31
1980Q3	-0.95	0.24
1981Q3	-0.70	0.50
1981Q4	-0.51	0.56
1982Q1	-0.75	0.60
1982Q2	-1.38	0.87
1982Q3	-0.89	0.58
1982Q4	-0.94	0.72
1986Q4	-0.57	0.07
1990Q2	-0.28	0.32
1990Q3	-0.56	0.52
1990Q4	-0.90	0.67
1991Q1	-1.33	0.70
1995Q2	-0.09	0.19

C. Forecast Horizon of Two Quarters

Dates	Canada real GDP growth	Estimated probabilities
1980Q2	-0.44	0.33
1980Q3	-0.95	0.28
1981Q3	-0.70	0.39
1981Q4	-0.51	0.52
1982Q1	-0.75	0.63
1982Q2	-1.38	0.81
1982Q3	-0.89	0.53
1982Q4	-0.94	0.73
1986Q4	-0.57	0.07
1990Q2	-0.28	0.22
1990Q3	-0.56	0.38
1990Q4	-0.90	0.70
1991Q1	-1.33	0.66
1995Q2	-0.09	0.05

Note: The shaded area notifies that the probability to have a quarterly decline in the current quarter is higher than 50%.